SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SCOPE

A. Furnish all labor, materials, services and equipment as required in conjunction with or properly incidental to placing of concrete as described herein and/or as shown on the Drawings.

B. Includes all cast-in-place concrete building members. Refer to other sections for site concrete work.

C. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to Work of this section.

D. Alternate bids: Refer to other sections for description.

1.2 CODES AND STANDARDS

A. The Work described in this Section, unless otherwise noted on the Drawings, or herein specified, shall be governed by the latest editions of the following codes or specifications.

1. ACI 211.1-81, "Recommended Practice for Selecting Proportions of Normal Weight Concrete".

2. ACI 301, "Specifications for Structural Concrete for Buildings".

3. ACI 304, "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete".

4. ACI 305, "Hot Weather Concreting".

5. ACI 306, "Cold Weather Concreting".

6. ACI 309, "Standard Practice for Consolidation of Concrete".

7. ACI 311, "ACI Manual of Concrete Inspection".

8. ACI 318, "Building Code Requirements for Reinforced Concrete".

9. ASTM C33, Standard Specification for Concrete Aggregate.

10. ASTM C94, Standard Specification for Ready-Mix Concrete.

11. ASTM C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

12. ASTM C150, Standard Specification for Portland Cement.

13. ASTM C260, Standard Specification for Air-Entraining Admixtures.

14. ASTM C330, Standard Specification for Lightweight Aggregates for Structural Concrete.

15. ASTM C494, Standard Specification for Chemical Admixtures for Concrete.

16. ASTM C595, Standard Specification for Blended Hydraulic Cements.

17. ASTM C617, Practice for Capping Cylindrical Concrete Specimens

18. ASTM C618, Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.

19. ASTM C1074, Standard Practice for Estimating Concrete Strength By The Maturity Method.

1.3 QUALITY ASSURANCE

A. Source Quality Control:

1. Concrete production facilities shall meet the requirement for certification by the National Ready Mixed Concrete Association.

2. Concrete batchers shall be completely interlocked semi-automatic or automatic batchers, as defined by the Concrete Plant Manufacturers Bureau.

3. Concrete batchers shall have graphic, digital, or photographic recorders, which shall register both empty balance and total weight (or volume of water or admixture) of each batched material, time to the nearest minute, date, identification of batch, and numerical count of each batch. Copies of the record shall be furnished to the Testing Laboratory.

4. The Testing Laboratory shall provide concrete batch plant inspection as follows:

a. Provide a qualified inspector with necessary equipment and apparatus to inspect weighing and batching of controlled concrete at batch plant on a random basis, approximately once daily as the concrete is being placed on this project.
b. Make certain that materials and batch equipment used are in accordance with requirements of Specifications.
c. Check for adjustment in batch weights to compensate for variations in moisture content.
d. Submit promptly to Architect, certification of weights used in loads of acceptable concrete which has been batched during plant inspection time.

B. Concrete Mix Design Criteria

1. Design concrete mixes in accordance with Part 2 of this Section.

2. For each concrete mix type proposed, make trial mix using aggregate proposed.

3. Determination of required average strength above specified strength shall be in accordance with ACI 318.

4. Make advance tests of trial mixes with proposed materials. Mold and cure test cylinders in accordance with ASTM C39. Do not place concrete on project until laboratory reports and results of confirmation cylinder tests have been evaluated by the Testing Laboratory and results indicate that proposed mixes will develop required strengths.

5. Testing Laboratory shall furnish the Architect with a written evaluation of each proposed concrete mix design submitted by the Contractor.

6. Check mix designs and revise if necessary wherever changes are made in aggregates or in surface water content of aggregate or workability of concrete. Slump shall be minimum to produce workable mix. Laboratory shall prescribe maximum quantity of water.

1.4 SUBMITTALS

A. Mix Designs: The Contractor shall submit proposed mix designs in accordance with ACI 318, Section 5.3 to the Testing Laboratory and structural engineer for evaluation a minimum of 14 days prior to placing concrete. Show:

1. Proportions of cement, including fly ash content, fine and coarse aggregates, and water.

2. Combined aggregate gradation.

3. Aggregate specific gravities and gradations.

4. Water-cement ratio, design strength, slump and air content.

5. Type of cement and aggregates.

6. Type and dosage of admixtures.

7. Type, color and dosage of integral coloring compounds, where applicable.

8. Special requirements for pumping.

9. Range of ambient temperature and humidity for which design is valid.

10. Any special characteristics of mix which require precautions in mixing, placing, or finishing techniques to achieve finished product.

11. Test data showing an acceptable strength history as specified in Section 5.3 of ACI 318. For mixes specified as requiring concrete strengths of 7,000 psi or higher, regardless of age acceptance, minimum 30 consecutive tests shall be provided per ACI 318-5.3.1.1. Exceptions per ACI 318-5.3.1.2 and 5.3.3 shall not be allowed except as approved in writing by the structural engineer.

12. Test data showing modulus of elasticity for the specific mix proposed, if listed on contract documents. Compressive strength of MOE test cylinders shall not exceed specified concrete strength by more than 500 psi.

B. Mix designs based on trial mixes accordance with Section 5.3.3.2 of ACI 318 may be submitted in lieu of mix designs required above, provided all necessary information is included.

C. The Contractor shall furnish duplicate delivery tickets for each load of ready-mix concrete delivered to site, in accordance with ASTM C94. Show batch weights on each ticket.

D. The Contractor shall furnish mill test reports on an as-used basis for each type and brand of cementitious material used, including fly ash.

E. The Testing Laboratory shall furnish a statistical analysis for each class of concrete placed on the project as specified in this section.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mix and deliver concrete to project ready-mixed in accordance with ASTM C94. Mix concrete a minimum of 70 revolutions of transit mix drum at mixing speed. A minimum of 40 revolutions shall be at the production plant.

B. Schedule delivery so that continuity of any pour will not be interrupted for over 15 minutes.

C. Place concrete on site within 90 minutes after proportioning materials at batch plant.

1.6 JOB CONDITIONS

A. Hot Weather Concreting:

1. Follow ACI 301 and ACI 305R.

2. Provide retarding type admixture conforming to ASTM C494, Type A or D in accordance with manufacturer's recommendations.
3. Maximum concrete temperature shall not exceed 95 degrees F at time of placement.
   a. Concrete with temperatures above 90 degrees F shall be placed only if a high range water reducer (super plasticizer) is added to the mix as directed by the Testing Laboratory to maintain the specified slump during placement.

B. Cold Weather Concreting: Protect concrete work from physical damage or reduced strength which could be caused by frost, freezing actions, or low temperatures.

1. Follow ACI 301 and ACI 306.1.

2. When ambient temperature at site is below 40 degrees F or is expected to fall to that temperature within ensuing 24 hours, heat water and/or aggregate prior to adding to mix so that temperature of concrete will be between 55 degrees F and 85 degrees F at time of placement.

3. Maintain temperature of deposited concrete between 50 degrees F and 70 degrees F for minimum of seven days after placing.

C. Temperature Changes: Maintain changes in concrete temperature as uniformly as possible, but in no case exceed change of 5 degrees F per hour or 25 degrees F in any 24 hour period.

D. Combustion heaters shall not be used during the first 48 hours without precautions to prevent exposure of concrete and workmen to exhaust gasses containing carbon dioxide and/or carbon monoxide.

E. Admixtures intended to accelerate hardening of concrete or produce higher than normal strength at early periods will not be permitted unless approved by the Architect. The use of calcium chloride is specifically prohibited.

1.7 SEQUENCING/SCHEDULING

A. Coordinate Work of this Section with work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the work of other Sections.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cement/Fly Ash:

1. Portland Cement, Type I or III, conforming to the requirements of ASTM C150.

2. Fly Ash, Class C or F, conforming to the requirements of ASTM C618. The use of Fly Ash shall be subject to review by the Architect. Where Fly Ash is used in the mix design, Fly Ash shall comprise no more than 20% by weight of the total cementitious material in the mix for horizontal applications (slabs, beams, etc.). Where Fly Ash is used in the mix design, Fly Ash shall comprise no more than 30% by weight of the total cementitious material in the mix for vertical applications (columns, shearwalls, etc.).

B. Aggregate:

1. Fine: ASTM C33; clean, hard, durable, uncoated, natural sand, free of silt, loam or clay.

2. Coarse: ASTM C33; hard, durable, uncoated, crushed stone; gradation in accordance with Size No. 467 for piers and concrete footings and Size No. 67 for all other concrete. Maximum aggregate size in accordance with ACI 318.

3. Coarse aggregate for structural lightweight concrete shall conform to the applicable requirements of ASTM C330 suitably processed, washed and screened, and shall consist of durable particles without adherent coatings. Gradation in accordance with Size Designation 3/4 inch to No. 4, Table 1, ASTM C330.

4. Grading shall be in accordance with "Standard Method for Fine Analysis of Sieve and Coarse Aggregates" (ASTM C136).

C. Water: ASTM C94, Paragraph 4.1.3; potable, clean and free from oil, acid and injurious amount of vegetable matter, alkalies, and other impurities.

D. Admixtures:

1. Cement-dispersing, water-reducing types. Admixtures shall conform to ASTM C494, Type A or D, and shall be used strictly in accordance with manufacturer's recommendations and as determined by the Testing Laboratory. Admixture shall not discolor concrete or in any way affect the appearance of the concrete.
   a. High-range water reducing admixture conforming to ASTM C494, Type F, may be used as required and shall be one of the following types or equal:
      (1) Master Builders Rheobuild 1000/Glenium 3000 NS
      (2) SIKA Sikament
      (3) W.R. Grace WRDA-35

2. An air-entraining admixture conforming to ASTM C260 shall be used as required on the Drawings and shall be one of the following types or equal:
   a. Master Builders MB-VR
   b. SIKA AER
   c. W.R. Grace Darex AEA

3. Use of calcium chloride is specifically prohibited.

4. All Admixtures shall be certified by manufacturer to contain not more than 0.1% water-soluble chloride ions by mass of cementitious materials.

E. Non-Shrink Cement Grout:

1. Qualities: Premixed non-shrink grout requiring only addition of water. Non-metallic type grout where grout will be sight exposed.
   a. Minimum compressive strength of 5000 PSI at 7-days and 7500 PSI at 28-days when placed at a plastic consistency of 115% flow factor.
   b. Free of chloride, sulphates or gas producing agents.

2. Standards:
   a. Overall product: CRD-C-621.
   b. Compressive Strength: ASTM C109, 2 inch cubes.
   c. Bleed Performance: CRD C-611.
   d. Flow Factor: ASTM C230.

F. Miscellaneous Structural Metals Associated with Structural Concrete:

1. All structural steel pieces including miscellaneous structural metals placed in concrete exposed to weather, in permanent contact with soil, or accessible to salt intrusion shall be hot dipped galvanized in accordance with ASTM A123.

2. All structural steel pieces embedded in concrete shall conform to ASTM A36, unless noted otherwise on the Drawings.

3. Welding of inserts, anchors and other steel pieces used in conjunction with structural concrete shall conform to AWS D1.1.

4. Welding of reinforcing steel used in conjunction with structural concrete shall conform to AWS D1.4.

5. Headed stud anchors shall conform to ASTM A108, minimum tensile strength 60,000 PSI.

6. Concrete expansion anchors shall be wedge-type anchors, meeting the requirements of Federal Specification FF-S-325, Group II, Type 4, Class 1, plated in accordance with Federal Specification QQ-Z-325C, Type II, Class 3. Size and location shall be as indicated on the Drawings.

2.2 CONCRETE MIXES

A. Strength: Concrete is classified and specified by ultimate compressive strength (f'c) at the age of 28 days or 56 days as indicated by the contract documents.

B. Design concrete to yield strengths indicated on the Drawings.

C. Proportions: Proportions of cement, aggregate, and water to attain required plasticity and compressive strength shall be in accordance with ACI 318. Do not make changes in proportions without submitting proposed changes to Testing Laboratory for evaluation.

1. Mix designs furnished by the concrete supplier, and accompanied by test data showing an acceptable strength history meeting the requirements as specified in section 5.3 of ACI 318, will be considered an acceptable alternative to the procedure described in paragraphs below.
   a. Temperature of concrete in test data shall be within 5 degrees F of maximum temperature specified for this project.
   b. Strengths indicated in test data shall be in accordance with ACI 318, Section 5.3.2.
   c. The specified strength of concrete used in supporting test data shall vary no more than 500 PSI plus or minus from that specified for this project.

2. If test data showing an acceptable strength history is not available trial mixtures as specified in Section 5.3.3.2 of ACI 318 having proportions and consistencies suitable for the work shall be made based on ACI 211.1, using at least three different water-cement ratios which will produce a range of strengths encompassing those required for this project. This method shall not be used for concrete specified at f'c=7,000 psi or greater.
   a. Trial mixes shall be designed to produce a slump within 3/4" of the maximum permitted, and for air-entrained concrete, within 0.5 percent of maximum allowable air content. The temperature of concrete used in trial batches shall not exceed the maximum temperature specified.
   b. For each water-cement ratio, at least three confirmation compression test cylinders for each test age shall be made and cured in accordance with ASTM C192. Confirmation cylinders shall be tested at seven and twenty-eight days in accordance with ASTM C39.
   c. From the results of the twenty-eight day confirmation tests, a curve shall be plotted showing the relationship between the water-cement ratio and compressive strengths. From this curve, the water-cement ratio to be used in the concrete shall be selected to produce the average strength required.
   d. The cement content and mixture proportions to be used shall be such that this water-cement ratio is not exceeded when slump is the maximum permitted. Control in the field shall be based upon maintenance of proper cement content, slump and air content.

3. The Testing Laboratory shall keep a strength history record of all concrete for the duration of the project as specified in this section.

PART 3 - EXECUTION

3.1 GENERAL

A. Inserts: Give the various trades and subcontractors ample notification and opportunity to furnish any and all anchors, nailers, pipes, conduits, boxes, inserts, thimbles, sleeves, frame vents, wires, supports, or other items required to be built into the concrete by the provisions of the Drawings or of the Specification governing the work of such trades and subcontractors, or as it may be necessary for the proper execution of their work. Obtain suitable templates or instructions for the installation of such items which are required to be placed in the forms.

B. Slump:

1. Concrete not containing a high range water reducing admixture shall not be placed when its plasticity, as measured by slump test, is outside the following limits:

Unit Slump

All Structural Concretez: " maximum, 3" minimum.

2. Concrete containing a high range water reducing admixture shall not be placed when its plasticity, as measured by slump test, is outside the following limits:
   a. Prior to addition high range water reducer: 3 inch maximum, 1 inch minimum.
   b. After addition of high range water reducer: 10 inch maximum.

C. Classes of Concrete and Usage: Concrete of the several classes of concrete required shall have the characteristics shown on the Drawings.

D. Mixing:

1. Transit-mixed concrete conforming to the requirements of ASTM C94, ACI 304 and ASTM C1116 shall be used in lieu of concrete mixed at the job site. Concrete shall not be transported or used in any case after a period in excess of ninety (90) minutes has elapsed after the introduction of water into the mixer.

2. Indiscriminate addition of water to increase slump of concrete is prohibited. Add water only at the direction of the Testing Laboratory. No water shall be added which increases the water cement ratio of the concrete in excess of the water cement ratio indicated on the approved mix design. At the direction of the Testing Laboratory the addition of a high range water reducing admixture may be used to retemper concrete.

3. The agency supplying transit-mixed concrete shall have a plant of sufficient capacity and adequate transportation facilities, to assure continuous delivery at the rate required. The frequency of deliveries to the site of the work must be such as to provide for placing the concrete continuously throughout any one (1) pour.

E. Conveying Concrete: Convey concrete from the mixer to the place of final deposit by methods which will prevent the separation or loss of the ingredients. Concrete to be conveyed by pumping shall be submitted to the Testing Laboratory for evaluation for each class of concrete specified before being used. Test cylinders for pumped concrete shall be taken at the discharge end of the pumping equipment.

F. Equipment for chuting, pumping, and pneumatically conveying concrete shall be of such size and design as to assure a practically continuous flow of concrete at the delivery end without separation of the materials. The use of gravity-flow or aluminum chutes or conveyors for transporting concrete horizontally will not be

permitted.

3.2 CONCRETE CONTROL AND TESTING

A. Testing laboratory services shall be in accordance with Section 01 45 29.

B. Sample and test concrete placed at the job site in accordance with ASTM C172. Each sample shall be obtained from a different batch of concrete on a random basis.

C. All concrete shall be tested as follows:

1. For concrete with an acceptance age of 28 days, mold and cure five (5) specimens from each sample in accordance with ASTM C31.

2. Two (2) specimens shall be tested at seven days for information, two shall be tested at 28 days for acceptance, and the remaining cylinder shall be tested as directed.

3. For concrete with an acceptance age of 56 days, mold and cure seven (7) specimens from each sample in accordance with ASTM C31.

4. Two (2) specimens shall be tested at seven days for information, two shall be tested at 28 days for information, two shall be tested at 56 days for acceptance, and the remaining cylinder shall be tested as directed.

5. If maturity methods are used for early strength verification for horizontal construction, one (1) 7 day cylinder may be omitted for each class of concrete.

D. Specimens for pumped concrete shall be taken at the discharge end of pumping equipment.

E. Any deviations from the requirements of ASTM Specifications shall be recorded in the test report. Test concrete specimens in accordance with ASTM C39. All specimens for concrete specified f'c = 7,000 psi or greater shall be capped in accordance with ASTM C617. Strength of capping material to be used shall exceed required compressive strength of sample by at least 2,000 psi.

F. Make at least one strength test (five or seven specimens) for each 100 cu. yd. or fraction thereof, of each mix design of concrete placed in any one day. Determine slump of the concrete sample for each strength test and whenever consistency appears to vary, in accordance with ASTM C143. Concrete for columns exceeding f'c = 5000 psi shall have one strength test for each 50 cu. yd. or fraction thereof, of each mix design of concrete placed in any one day.

G. Determine air content of air-entrained, normal weight and/or lightweight, concrete

sample for each strength test in accordance with either ASTM C231 or ASTM C173. Determine the unit weight of the concrete sample for each strength test.

H. Inspect each batch of concrete, monitor addition of mixing water to assure uniform consistency from truck to truck. Check mixing form mixers before mix begins to set and within time limits set forth in ASTM C94.

1. Monitor addition of water and high-range water reducer to concrete at job site and length of time concrete is allowed to remain in truck during placement.

2. Certify each delivery ticket indicating class of concrete delivered, amount of water added and time at which cement and aggregate was discharged into truck, and time at which concrete was discharged from truck.

I. Should the strength of concrete fall below the minimum, then additional tests, including load tests, may be required. These tests, if required, shall be made at the Contractor's expense and shall be in accordance with ASTM C42 and ACI 318. If tests do not meet the applicable requirements, then the structure, or any part of the structure, shall be removed and replaced at the Contractor's expense.

J. Test reports shall include but not be limited to the following information: date of concrete placement, concrete mix identification number or proportion of ingredients, truck ticket number, time test was made, time of batching, location of each placement, slump, unit weight and air content of concrete sampled and date and results of strength test.

K. Report promptly to Architect all details of reasons for rejection of any and all quantities of concrete. Give all information concerning locations of the concrete pours, quantities, date of pours, and other pertinent facts concerning concrete represented by the specimens.

L. The General Contractor shall be responsible for making and curing concrete cylinders, cured under field conditions, for the purpose of determining concrete strength at time of form and shore removal. Such cylinders shall be made by and tested by the testing laboratory at the contractor’s expense. Alternatively, the in situ strength of concrete may be determined by the maturity method following the requirements of ASTM C 1074.

M. Furnish a statistical analysis for each class of concrete placed on the project in accordance with ACI 214-77 and ACI 318. Information shall be updated and distributed once a month as directed by the Architect.

For concrete with an acceptance of 28 days, Information shall include, but not be limited to, the following:

1. Strength tests at 7 days of 2 cylinder averages.

2. Strength tests at 28 days of 2 cylinder averages.

3. 28-day moving average strength tests of last 3 test groups.

4. Standard deviation and coefficient of variation based on 28 day strength tests.

5. Average strength and number of 28 days tests for most recent month.

For concrete with an acceptance of 56 days, Information shall include, but not be limited to, the following:

1. Strength tests at 7 days of 2 cylinder averages.

2. Strength tests at 28 days of 2 cylinder averages.

3. Strength tests at 56 days of 2 cylinder averages.

4. 56-day moving average strength tests of last 3 test groups.

5. Standard deviation and coefficient of variation based on 56 day strength tests.

6. Average strength and number of 56 days tests for most recent month.

3.3 PLACING CONCRETE

A. Place concrete in reasonably uniform layers, approximately horizontal, and not more than eighteen inches (18") deep, exercising care to avoid vertical joints or inclined planes. The piling up of concrete in the forms in such a manner as to cause the separation or loss of any of its ingredients will not be permitted. Concrete which has partially set or hardened shall not, under any circumstances, be deposited in the work.

B. Place concrete in the forms as nearly in its final position as is practical to avoid rehandling. Exercise special care to prevent splashing the forms or reinforcement with concrete. Remove any hardened or partially hardened concrete which has accumulated on the forms or reinforcement before the work proceeds. Do not place concrete on previously deposited concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the respective member of section, except as hereinafter specified.

C. Do not permit concrete to drop freely any distance greater than five feet (5'). Where longer drops are necessary, use a chute, tremie, or other acceptable conveyance to assist the concrete into place without separation. Do not pour directly into any excavations where water is standing.

D. Vibration: As soon as concrete is deposited, thoroughly agitate same by means of mechanical vibrators and suitable hand tools, so manipulated as to work the mixture well into all parts and corners of the forms, and entirely around the reinforcement and inserts. Mechanical vibrators shall maintain frequencies in accordance with the recommendations of ACI 309R. Table 5.1.4, and shall be operated by competent workmen. Over vibrating and use of vibrators to transport concrete within forms shall not be allowed. A spare vibrator shall be kept on the job site during all concrete placing operations.

E. Bonding: Before depositing any new concrete on or against previously deposited concrete which has partially or entirely set, the surface of the latter shall be thoroughly roughened and cleaned of all foreign matter, scum and laitance.

F. Construction Joints: Except as otherwise specifically indicated on the Drawings, each concrete member shall be considered as a single unit of operation, and all concrete for the same shall be placed continuously in order that such unit will be monolithic in construction. Should construction joints prove to be absolutely unavoidable, same shall be located at or near the midpoints of spans. Additional construction joints shall not be made under any circumstances without prior review by the Architect.

G. Protect all freshly placed concrete from washing by rain, flowing water, etc. Do not allow the concrete to dry out from the time it is deposited in the forms until the expiration of the curing period.

H. Refer to structural drawings for column base plate and other structural grouting requirements.

I. Grout shall be mixed only in such quantities as are needed for immediate use. No retempering shall be permitted and materials which have been mixed for a period exceeding thirty (30) minutes shall in no case be used upon any portion of the work.

J. Imperfect or damaged work, or any material damaged or determined to be defective before final completion and acceptance of the entire job, shall be satisfactorily replaced at the Contractor's expense and shall be in conformity with all of the requirements of the Contract Documents. Removal and replacement of concrete work shall be done in such a manner as not to impair the appearance or strength of the structure in any way.

K. Cleaning: Upon completion of the work, all forms, equipment, protective coverings and any rubbish resulting there from shall be removed from the premises. Finished concrete surfaces shall be left in clean and perfect condition, satisfactory to the Owner. Sweep with an ordinary broom and remove all mortar, concrete droppings, loose dirt, mud, etc.

3.4 GROUT

A. For every one-third (1/3) cubic yards of grout placed, grout strength shall be tested with a set of cubes as follows:

1. A set of cubes shall consist of three cubes to be tested at 7 days, and three cubes to be tested at 28 days.

2. Test cubes shall be made and tested in accordance with ASTM C109, with the exception that the grout should be restrained from expansion by a top plate.

3.5 FIELD QUALITY CONTROL AND TESTING

A. Testing Laboratory services shall be in accordance with Section 01 43 26. Provide all inspections and testing as required by the 2006 International Building Code.

END OF SECTION

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